



# Focal Plane Array Shutter Mechanism

of the JWST NIRSpec Detector System

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## Outline



- Requirements
- Chamber location
- Shutter system design
- Motor specs
- Dry lubrication
- Control system
- Environmental cryogenic function testing
- Test results
  
- Acronyms
  - FPA- Focal Plane Assembly
  - SCA- Sensor Chip Assembly
  - JWST – James Webb Space Telescope
  - NIRSpec – Near Infrared Spectrum



## Derived Requirements



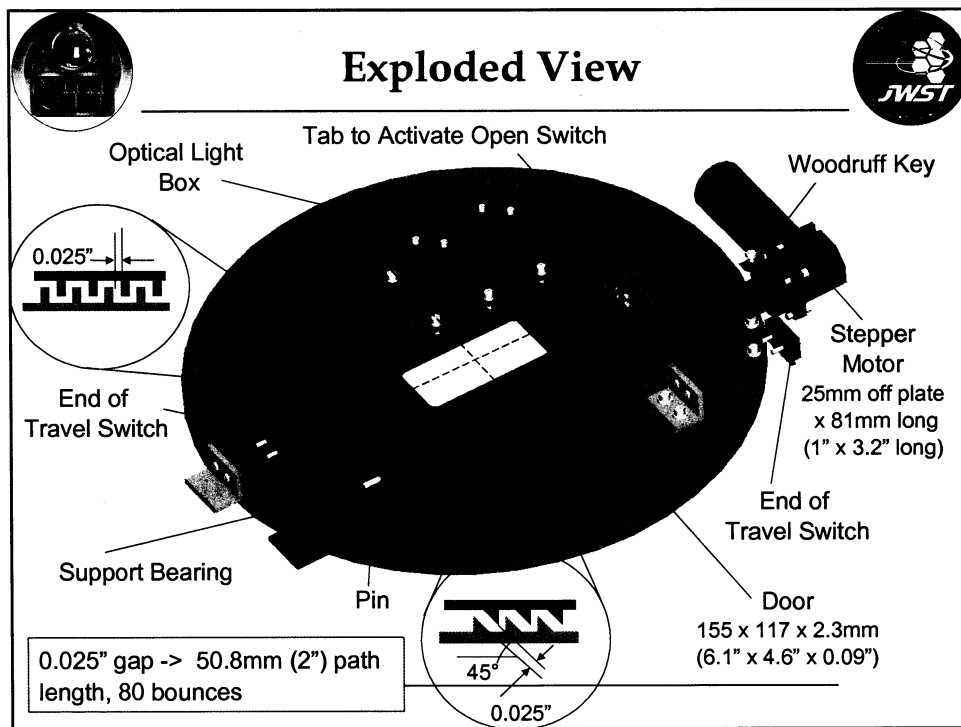
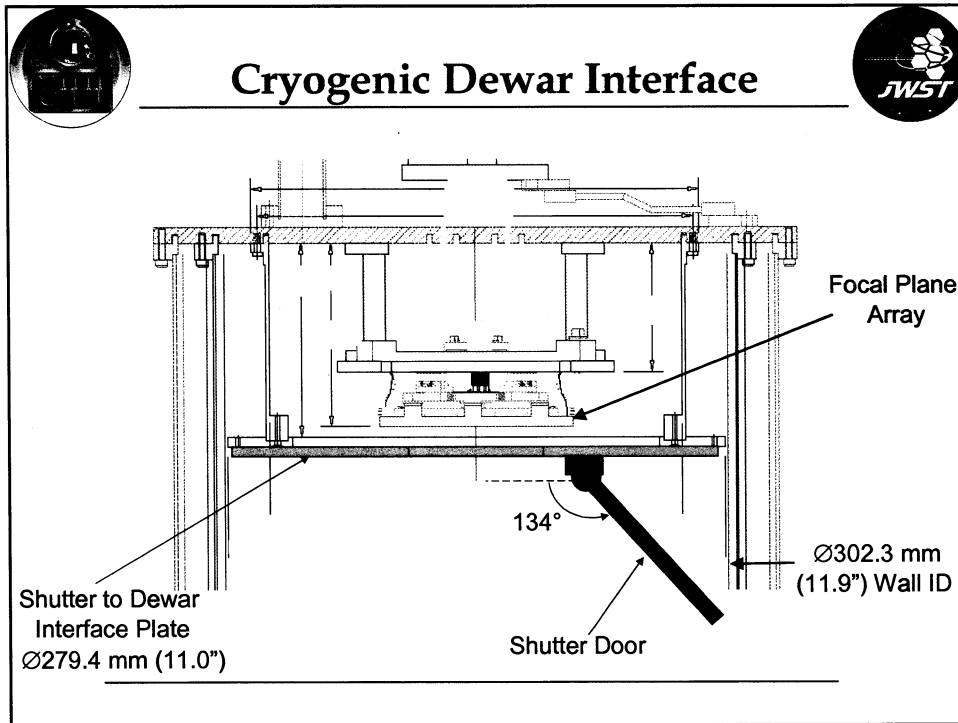
- Light baffle mechanism for ground testing for NIRSPEC FPA
  - 1 degree of freedom operation
  - Operate in vacuum ( $10^{-6}$  Torr) – mechanism not required to hold vacuum
  - Open or close shutter in about one minute
  - Operate through several thousand cycles over life
  - Fit within “Experimental Shell” diameter Ø302 mm (Ø11.9”) envelope and on Ø279mm (Ø11.0”) plate
  - Keep maximum height, at any time during operation, <228.5 mm (9”)
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## Derived Requirements

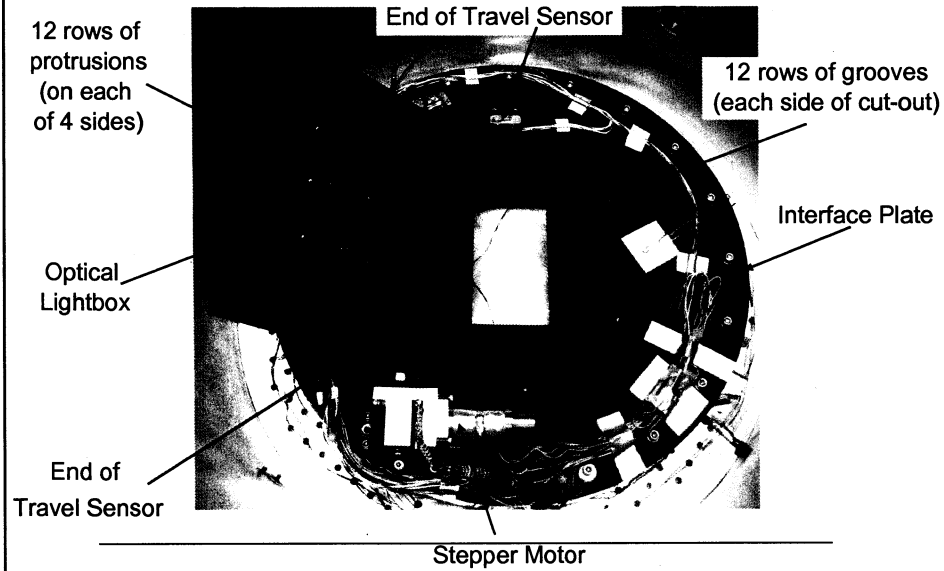


- Light tightness
    - Required attenuation =  $1 \text{ E}4$
    - Path length designed for specified gap distance
    - Door rotation  $>90^\circ$
  - Temperature
    - Operating:  $-253^\circ\text{C}$  to  $27^\circ\text{C}$  (20K to 300K)
  - Operate in any direction 1g field
    - Hold position with power off in any direction 1g field
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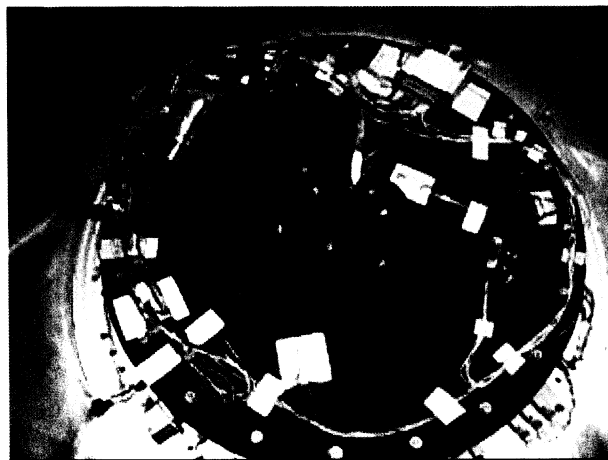




## Shutter in Open Configuration



## Shutter in Motion





## Stepper Motor



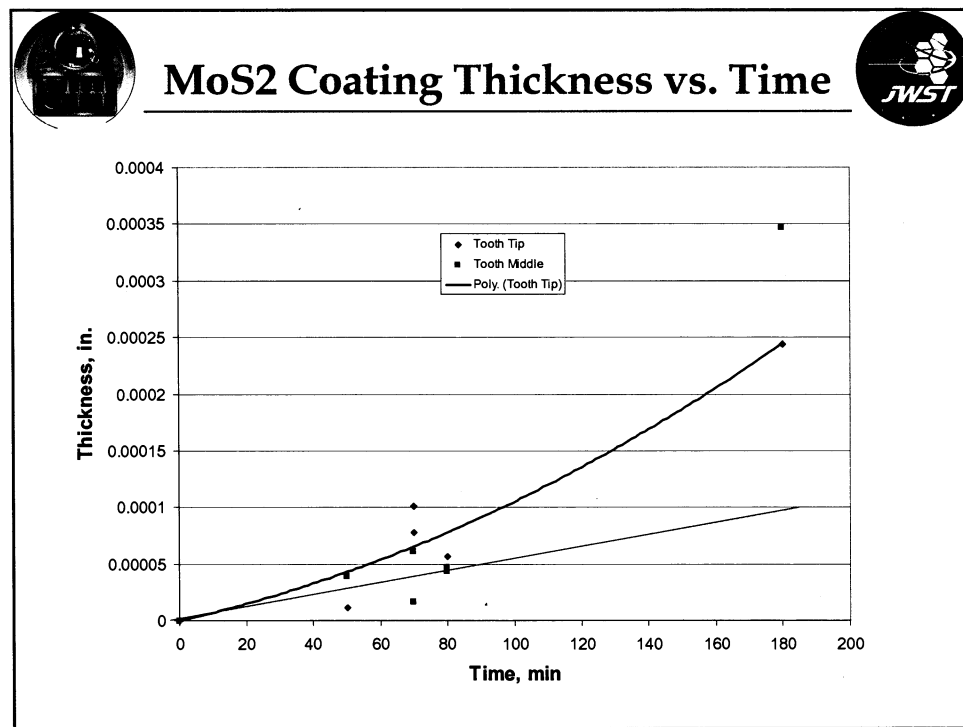
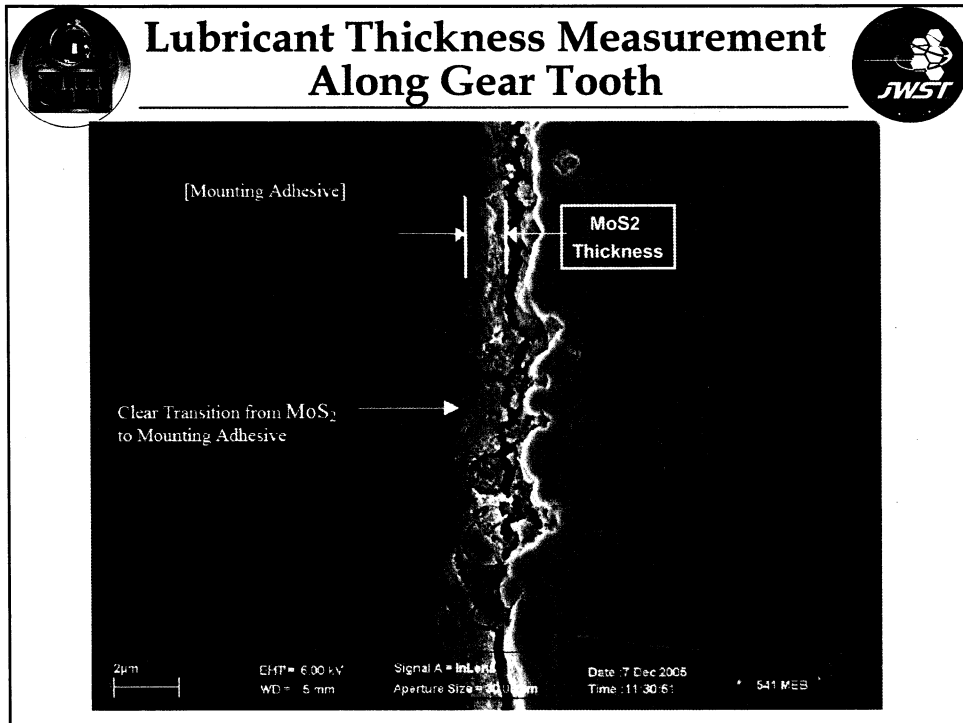
- Requires 0.0107 kg m<sup>2</sup> (0.155 oz. in<sup>2</sup>) to move door
    - Includes inertia of door and light box
  - Requires 0.095 N m (0.84 in. lb) of detent torque (3.2x margin)
  - Stepper Motor Requirements
    - 2 phase
    - 186.7 gear ratio
    - 30 degrees/step
    - Right angle gear head
    - Dry lubrication
- 0.16° per step  
resolution at output

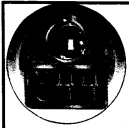


## Dry Plating Process for Stepper Motor

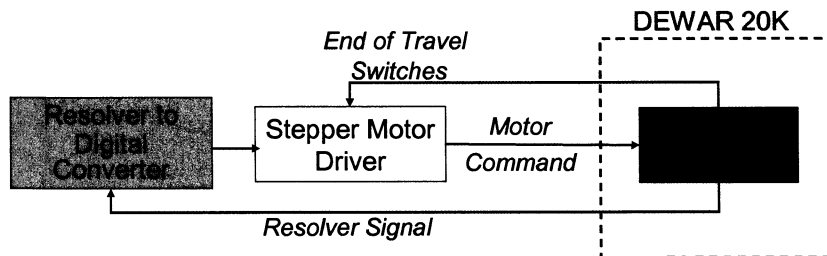


- Actuator bearings and gear train parts are lubed with Molybdenum Di-Sulfide
- 22 parts per motor
- We required 0.0001" thick coating
  - Thickness required was determined by maximum thickness allowed due to motor part tolerancing
- Contamination not an issue as motor is contained within a closed volume





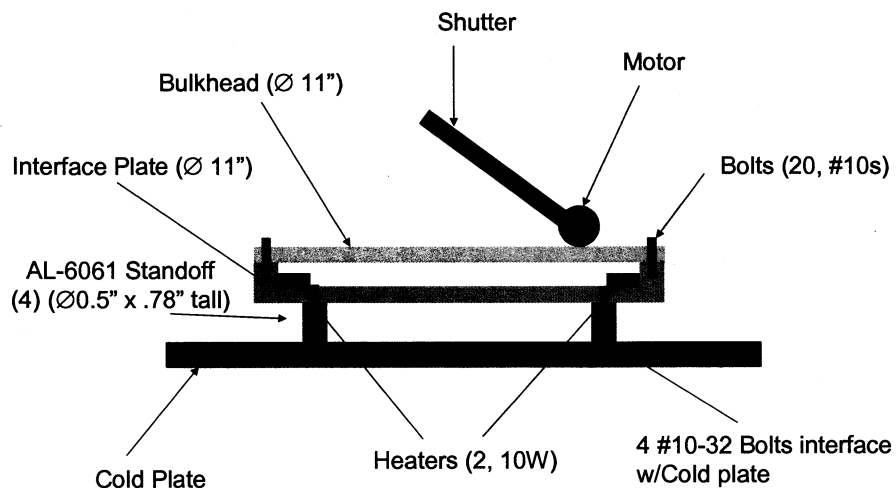
## Electrical System & Control

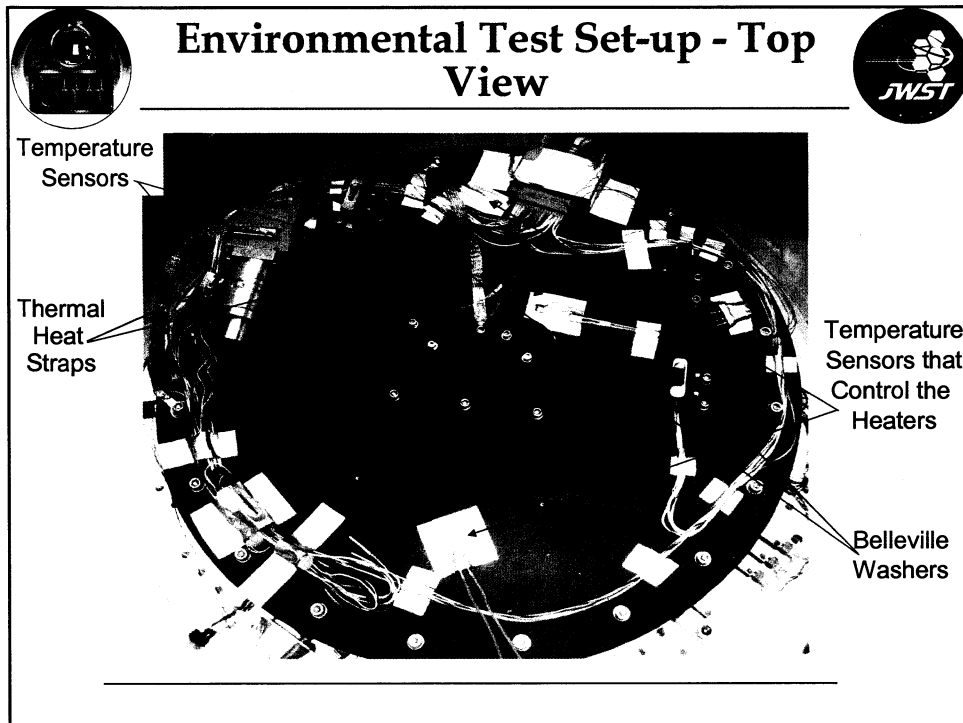


- National Instrument (NI) ESP 300 series stepper controller (3 amp/axis)
- Used resolver and both switches for feedback and control
- Constant current source to motor



## Environmental Verification Test Set-up - Side View

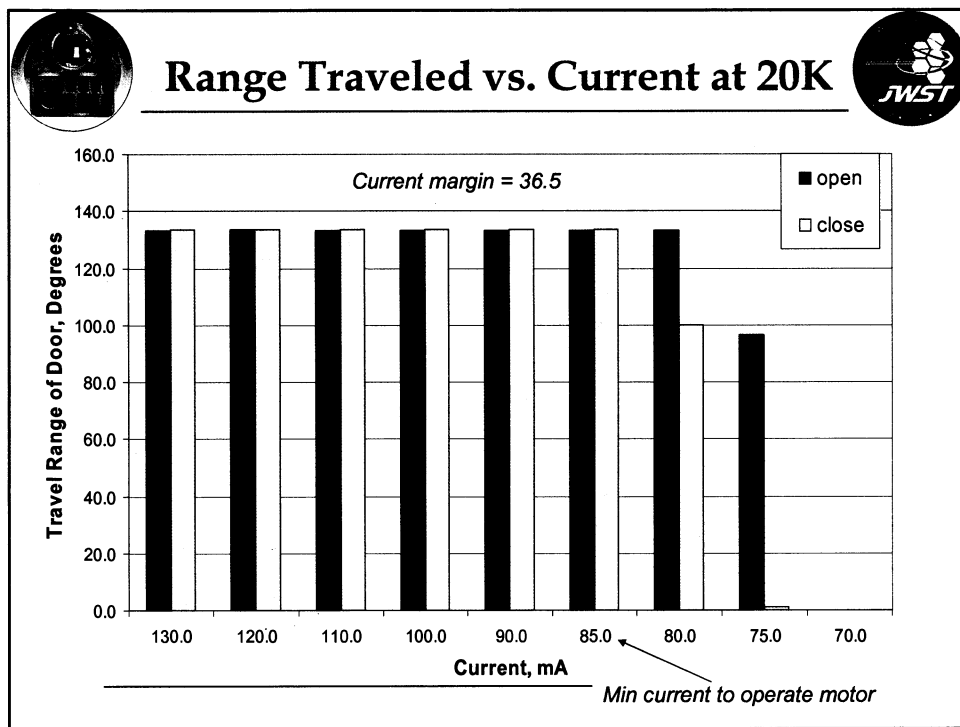
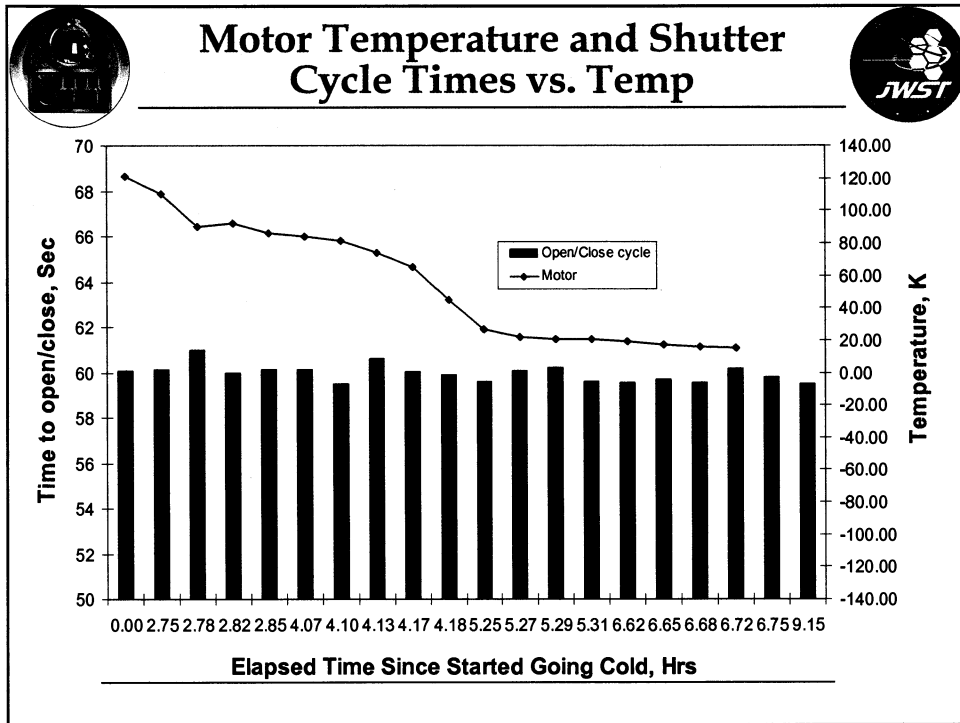




**Environmental Test Set-up**

- Radial support bearing already dry lubricated by a cage that wears away and provides lubricant
  - Bearing mount made of AL-6061. Calculations performed to ensure CTE mismatch would not affect bearing performance
- Cryogenic compatible end-of-travel sensors purchased
  - Were designed by manufacturer for cryogenic environment but were not previously tested
  - Tested in house by slowly introducing into liquid Nitrogen







## Lessons Learned – Cryogenic Testing

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- Verify all solder connections so ensure connections will not separate when reach cryogenic temperatures
  - Check and re-check all electrical connections before buttoning up the chamber
  - Use Belleville washers to keep interfaces tight through thermal changes
  - Light tightness will be tested when integrated into project's cryogenic dewar with the detectors
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